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REVIEW

Essential Oils and Biological Activities of the Genus *Vitex* (Lamiaceae) – A Review

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Abstract

The genus *Vitex* which includes approximately 270 species, and is an important genus of the Lamiaceae family due to its production of secondary compounds. The plants are generally used in preventing women's complaints such as aging, menstrual, menopausal, breast disease, and infertility. The objective of this study was to carry out a review of essential oils of the genus *Vitex* and their biological activities. The data were collected from the scientific electronic databases including SciFinder, Scopus, Elsevier, PubMed, and Google Scholar, within miscellaneous scopes of the *Vitex* include either medicinal uses or essential oil studies from a different region of countries. A total of nineteen *Vitex* species have been reported for their essential oils and biological activities. It can be observed that the major components were caryophyllene, germacrene D, limonene, *cis*-calamenene, 1,8-cineole, and spathulenol. Pharmacological studies indicated that the essential oil exhibited antioxidant, antimicrobial, anti-inflammatory, antifungal, acaricidal, antibiofilm, larvicidal, cytotoxic, and acetylcholinesterase activities. This review is mainly meant to provide relevant information on the phytochemical features of *Vitex* species, with emphasis on the essential oil, providing guidance, or the selection of accessions or species with the best chemical profiles. Nonetheless, it seems clear that more clinical evaluations are required until essential oils can be considered as possible applications in pharmacy or as adjuvants to current medications.

Keywords: Essential oils, *Vitex*, Lamiaceae, caryophyllene, antimicrobial

Introduction

Essential oils are complex mixtures of volatile compounds that are produced by aromatic plants as secondary metabolites. They are responsible for the aromatic plant's properties, and for this reason, they are characterized by their strong smells (Salleh et al., 2011, 2012). In general, essential oils are liquid, volatile, and soluble in lipids and organic solvents. They can be present in all plant organs, including buds, flowers, leaves, seeds, stems, flowers, fruits, roots, wood, or bark. Different extraction techniques are widely employed for the extraction of essential oils such as steam distillation, solvent extraction, and supercritical fluid extraction (Salleh et al., 2014a, 2014b, 2014c). These essential oils are characterized by the presence of variable mixtures of bioactive compounds, mainly terpenoids, especially monoterpenes and sesquiterpenes. In contrast, the essential oils have been commercialized as a source of potential herbicides and pesticides, aromatherapy and perfumes, foods and beverages, valuable dyes, and petro crops besides being used as health care products (Salleh et al., 2015a, 2015b, 2015c). Nowadays, researchers around the world produce medicines from the essential oils of natural products such as plants. The Lamiaceae plant species have diverse biological activities in their essential oils. Within 236 genera in the Lamiaceae family, the *Vitex* genus has been subjected to the most abundant available studies on its ethnobotanical profiles to discover the priceless potentials.

The genus *Vitex* constitutes approximately 270 species generally are trees and shrubs, with woody stems about 3 meters in height (Wang & Weller, 2006). They are widely distributed in tropical and subtropical regions such as Brazil, Nigeria, Turkey, Thailand, Vietnam, Algeria, and South Africa. Moreover, there are some species growing in the temperate zone as Iran, Montenegro, and all Europe countries (Devi and Singh,

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2014). The *Vitex* plant with the local name of *Five-Finger* and as a female herb has been used in traditional medicine and reported to have a variety of biological activities (Li et al., 2002). For instance, *Vitex* species broadly practiced for medicinal purposes are *V. negundo, V. agnus castus,* and *V. trifolia*. The leaves and seeds of *V. negundo* are extensively helpful for the treatment of rheumatism and inflammatory joint conditions (Callmander et al., 2014). The fruits of *V. agnus castus* fruits in Turkey are established in the effectiveness of women complaints such as female hormonal disorder, pre-menstrual disorder, menopausal remedy, treat aging and to improve vaginal lubrication (Ahangarpour et al., 2016). Besides, the leaves of *V. trifolia* are used to treat intestinal ailments, tuberculosis, amenorrhea, rheumatic, inflammation, sprains, wound healing, and fevers (Devi & Singh, 2014).

Hence, the review regarding *Vitex* essential oils has to be done to simplify and compile the information. However, *V. negundo*, *V. agnus castus,* and *V. trifolia* essential oils have been subject to the recent review, which will not be repeated here (Khan et al., 2019; Haghighi et al., 2019; Niazi et al., 2019; Niroumand et al., 2018; Suchitra & Cheriyan, 2018; Agalar et al., 2016; Toplan et al., 2015; Duymus et al., 2014; Rani & Sharma, 2013). The available information about *Vitex* essential oils of various species was searched thoroughly via electronic search (Pubmed, SciFinder, Scopus, Google Scholar, and Web of Science) and the articles published in peer-reviewed journals were collected via library search. The review aims to compile the information regarding their medicinal uses, chemical composition, and bioactivities of the essential oils from the genus *Vitex*.

Medicinal uses of the genus *Vitex*

This review emphasizes the traditional uses and clinical potential of several *Vitex* species. Through this review, the authors intend to highlight the unexplored potential of the *Vitex* species. This genus needs to be investigated systematically so that potential species can be exploited as therapeutic agents. Various medicinal plants had been analysed by the plant researchers to match their therapeutic values and to divine the safety to human consumption. The genus *Vitex* is generally well-known for the treatment of female disorders, sexual dysfunctions, and inflammations. Table 1 shows the medicinal uses of several *Vitex* species.

Table 1. Medicinal uses of several *Vitex* species

Species	Part	Medicinal uses
V. altissima	Fruits	To treat stomatitis, cardiac diseases, anorexia, blindness, leprosy, worm infestation (Yoganarasimhan, 2000)
V. buchananii	Leaves	To treat venereal diseases (Cabral et al., 2009)
V. cannabifolia	Fruits	To treat analgesia, cough, used as anti-tussive (Yamasaki et al., 2008)
V. congolensis	Leaves	To cure cicatrisation (Cabral et al., 2009)
V. diversifolia	Barks	To cure tooth and skin diseases, headache, intestinal bilharzias (Zerbo et al., 2011)
V. doniana	Barks	To treat gastroenteritis, diarrhea, and dysentery (Kilani, 2006)
V. ferruginea	Leaves	To cure skin diseases, mouth sore, snake-bite (Cabral et al., 2008)
V. gaumeri	Leaves	To treat colds, cough spelling, diarrhea, gastrointestinal affections (Damayanti et al., 1996)
V. leucoxylon	Leaves	To relieve headache, catarac, as a medicinal bath for fever and anemia, reduced cholesterol, anti-inflammatory (Makwana et al., 1994)
V. lucens	Leaves	To relieve sprains, backache, treating ear ulcers, sore throats, for dead's people body wash (Dykgraaf, 1992)
V. madiensis	Leaves	To treat skin disease (Cabral et al., 2009)
V. madiensis	Leaves	To prevent malaria (Ondo et al., 2012)

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V. megapotamica	Leaves	Used as a diuretic, hypocholesterolemic, recover skin problems, for treating hemorrhoids, uric acid problem, high blood pressure, inflammation of the uterus, bladder and prostate disorder (Alice et al., 1995)
V. mollis	Leaves	As a remedy to alleviate dysentery, analgesic, anti-inflammatory medicine, relieve scorpion stings, diarrhea, stomach ache (Rahman & Bhattacharya, 1982)
V. mombassae	Leaves	To treat a snake bite (Cabral et al., 2009)
V. peduncularis	Barks	To treat malaria fever (Geetha Nambiar, 1999)
V. pinnata	Roots	To relieve backache, body ache and fatigue (Kok, 2008)
V. piramidata	Leaves	To treat diarrhea, gastrointestinal affections (Ahmad & Holdsworth, 1995)
V. polygama	Leaves	To block acyclovir-resistant herpes simplex virus from propagate (Gonçalves, 2001)
V. pubescens	Leaves	To treat diarrhea, gastrointestinal affections (Ahmad & Holdsworth, 1995)
V. rivularis	Leaves	To treat skin and nail problems, used as a tea (Cabral et al., 2009)
V. rotundifolia	Fruits	To calm headaches, fever, eye infection (Ono et al., 2002)
V. simplicifolia	Leaves	To cure malaria, infant tetanus, dermatoses, dermatitis, headaches, bilharzia, muscle aches, fever, toothache, colic, amoebiasis (Koudou et al., 2014)
V. strickeri	Leaves	To treat a snake bite (Cabral et al., 2009)
V.cymosa	Leaves	To prevent insect bite and sting (Tereza et al., 2001)

Chemical Composition of *Vitex* Essential Oils

Analysis of chemical components identified in *Vitex* essential oils shows that the oil consists of several groups of components, which are monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons, and oxygenated sesquiterpenes. Table 2 shows the major components identified in *Vitex* essential oils from various origins.

Table 2. Major components identified from *Vitex* essential oils

Species	**Country**	**Part**	**Total identified (%)**	**Major components**
V. capitata	Brazil	Leaves	95.2	δ-Cadinene (7.1%), viridiflorene (5.2%) (De Sena Filho et al., 2017)
V. cymosa	Brazil	Leaves	40.96	β-Copaene-4-α-ol (9.78%), caryophyllene oxide (6.46%), β-bisabolene (5.16%), cubenol (5.09%) (Leitao et al., 1999)
V. diversifolia	South Africa	Leaves	99.4	Limonene (74.2%), caryophyllene oxide (3.2%) (Ch. Nebie et al., 2005)
V. doniana	Nigeria	Leaves	92.6	β-Phellandrene (31.3 %), phytol (28.3 %), β-caryophyllene (12.6 %) (Sonibare et al., 2009)
V. ferruginea	South Africa	Aerial parts	83.4-90.8	Germacrene D (26.8-34.9%), β-phellandrene (3.0-10.7%), β-caryophyllene (4.0-6.9%) (Cabral et al., 2008)
V. gardneriana	Brazil	Leaves	95.9	*cis*-Calamenene (29.7%), 6,9-guaiadiene (14.5%), caryophyllene oxide (14.0%) (Vale et al., 2019)
			94.71-95.20	*cis*-Calamenene (24.45-35.62%), 6.9-guaiadiene (12.47-28.86%), caryophyllene oxide (16.06-10.13%) (Silva et al., 2019)
			91.4-94.7	*cis*-Calamenene (29.7%), 6,9-guaiadiene (14.5%), caryophyllene oxide (14.0%) (Pereira et al. 2018)
	Brazil	Leaves	90.4	6,9-Guaiadiene (19.3%), caryophyllene oxide (18.6%), L-calamenene (13.9%), (De Sena Filho et al., 2017)
V. kwangsiensis	China	Seeds	93.1	Methyl linoleate (11.2%), caryophyllene oxide(10.3%), β-eudesmol (9.1%), methyl palmitate (8.1%) (Tian & Liu, 2018)
V. limonifolia	Thailand	Leaves	97.31	Caryophyllene (43%), caryophyllene oxide (13%) (Suksamrarn et al.,1990)

V. megapotamica	Brazil	Leaves	92.36	Butylated hydroxytoluene (34.17%), phytol (12.66%), α-caryophyllene (11.84%), δ-elemene (10.65%), β-caryophyllene (7.82%) (De Brum et al., 2013)
	Brazil	Leaves	96.8	(*E*)-Caryophyllene (16.2%), γ-muurolene (13.5%), α-copaene (10.8%) (De Sena Filho et al., 2017)
V. obovata	South Africa	Aerial parts	82.83	1,8-Cineole (11.69%), α-copaene (7.39%), caryophyllene oxide (5.94%) (Nyiligira et al., 2004)
V. obovate ssp. wilmsii	South Africa	Aerial parts	82.23	α-Copaene (11.79%), 1,8-cineole (7.18%) (Nyiligira et al., 2004)
V. pooara	South Africa	Aerial parts	97.97	Limonene (19.35%), β-selinene (14.41%), cryptone (10.05), humulene epoxide II (9.45%), caryophyllene oxide (7.45%) (Nyiligira et al., 2004)
V. polygama	Brazil	Leaves	37.71	(*E*)-Caryophyllene (11.27%), γ-elemene (5.03%), α-pinene (4.06%) (Leitao et al., 1999)
V. quinata	Vietnam	Leaves	92.1	β-Pinene (30.1%), β-caryophyllene (26.9%), β-elemene (7.4%) (Dai et al., 2015)
V. rehmannii	South Africa	Aerial parts	80.65	Spathulenol (8.06%), caryophyllene oxide (7.93%), elema-1,11-dien-15-ol (5.80%), caryophylla-2(12),6(13)-dien-5-α-ol (5.22%) (Nyiligira et al., 2004)
V. rivularis	Cameroon	Leaves	88.1-90.6	Germacrene *D* (12.6-20.6%), *ar*-curcume (9.1- 5.5%), γ-curcumene (7.8-9.7%), β-caryophyllene (7.3- 6.6%), α-copaene (6.4-5.0%) (Cabral et al., 2009)
V. rontudifolia	Korea	Leaves	70.7	α-Pinene (13.2%), α-terpineol (10.6%), 1,8-cineole (4.4%), manoyl oxide (4.0%) (Kim et al., 2014)
V. rufescens	Brazil	Leaves	97.8	(*E*)-Caryophyllene (21.0%), ledol (15.7%), germacrene *D* (9.3%), α-humulene (7.3%), *allo*-aromadendrene (6.9%), viridiflorene (6.6%), β-elemene (5.8%) (De Sena Filho et al., 2017)
V. zeyheri	South Africa	Aerial parts	82.27	1,8-Cineole (15.29%), globulol (5.46%), linalool (5.24%) (Nyiligira et al., 2004)

The major components of *Vitex* essential oils mainly consist of sesquiterpene hydrocarbons. Caryophyllene was identified as the major component of four *Vitex* species which are; *V. limonifolia* (Thailand) (Suksamrarn al., 1990), *V. polygama* (Brazil) (Leitao et al., 1999), *V. rufescens* (Brazil), and *V. megapotamica* (De Sena Filho et al., 2017). Besides, germacrene D was found in two different *Vitex* species which are; *V. ferruginea* (South Africa) (Cabral et al., 2008) and *V. rivularis* (Cameroon) (Cabral et al., 2009). In addition, the other sesquiterpene hydrocarbons were δ-cadinene (De Sena Filho et al., 2017), *cis*-calamenene (Vale et al., 2019; Silva et al., 2019; Pereira et al. 2018), 6,9-guaiadiene (De Sena Filho et al., 2017), which were found in the leaf oil of Brazillian *V. capitata*, *V. gardneriana*, and *V. gardneriana*, respectively. Meanwhile, spathulenol was found its richness in the oil of *V. rehmannii* (Nyiligira et al., 2004). Monoterpene hydrocarbons were also reported in *Vitex* essential oils. They were limonene (Ch. Nebie et al., 2005), β-phellandrene (Sonibare et al., 2009), α-copaene (Nyiligira et al., 2004), β-pinene (Dai et al., 2015), and α-pinene (Kim et al., 2014) which were extracted as high percentage in *V. diversifolia*, *V. doniana*, *V. obovata wilmsii*, *V. quinata*, and *V. rontudifolia* essential oils, respectively. In addition, the oxygenated monoterpenes were identified in *V. cymosa* (β-copaene-4-α-ol) (Leitao et al., 1999), *V. obovata* (1,8-cineole) (Nyiligira et al., 2004), and *V. zeyheri* (1,8-cineole) (Nyiligira et al., 2004) essential oils. On the other hand, another group of components that presents in *Vitex* essential oils were butylated hydroxytoluene and methyl linoleate, which were identified in the oils of *V. megapotamica* (De Brum et al., 2013) and *V. kwangsiensis* (Tian and Liu, 2018). It must be mentioned here that butylated hydroxytoluene is not a natural compound but an impurity.

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Biological Activities of *Vitex* Essential Oils

Antioxidant activity

The antioxidant activity of *V. kwangsiensis* was tested by DPPH• method and it showed weak antioxidant activity. A maximum concentration 1 mg/mL of oil was conducted and the radical scavenging activity was 26.76% (Tian & Liu, 2018). In another study, the ferrous ion chelating activity of the *V. gardneriana* essential oil showed the best activity at 7.81 µg/mL. Besides, the oil showed a dose-response relationship in β-carotene oxidation with the best activity at 500 µg/mL (Vale et al., 2019). De Brum et al., (2013) reported the *V. megapotamica* essential oil showed percentage inhibition of 35.62% and 75.25% at concentrations of 76 and 101.6 mg/mL against DPPH free-radical scavenging assay. However, this report should be read with caution since the main component in the oil is an antioxidant added to diethyl ether for protection.

Antimicrobial activity

The essential oil of *V. gardneriana* was able to inhibit the growth of *S. aureus* with a MIC of 0.31% v/v. However, no MIC was determined on *P. aeruginosa*. In addition, the essential oil showed about 70% to 9% and 30% - 3% of growth reduction on *C. albicans* and *C. tropicalis*, respectively (Vale et al., 2019). In another study, *V. gardneriana* essential oil gave value of 4.0 mg/mL against dermatophytes and yeasts; *C. albicans*, *C. tropicalis*, *C. parapsilosis*, *C. krusei*, and *T. rubrum* (Pereira et al., 2018). The *V. doniana* essential oil exhibited antimicrobial activity against *Proteus mirabilis*, *Bacillus subtilis,* and *Candida albicans* with inhibition zones of 11, 4 and 12 mm, respectively (Sonibare et al., 2009). The essential oils of *V. obovata* ssp. *obovata*, *V. obovata* ssp. *wilmsii*, and *V. zeyheri* gave MIC value 8.0 mg/mL against *S. aureus*, whereas *V. pooara* and *V. rehmannii* showed MIC value 32.0 and 16.0 mg/mL, respectively. In addition, *V. zeyheri* essential oil showed the best activity for *B. cereus* with MIC value 4.0 mg/mL (Nyiligira et al., 2004).

Anti-inflammatory activity

The essential oils of *V. pooara*, *V. rehmannii*, *V. obovata* ssp. *obovata*, *V. obovata* ssp. *wilmsii* and *V. zeyheri* reported the anti-inflammatory against 5-lipoxygenase assay with IC_{50} values of 25.0, 40.5, 42.0, 48.0, and 64.0 ppm, respectively (Nyiligira et al., 2004). The essential oil of *V. rotundifolia* suppressed LPS induced NO formation significantly in a dose-dependent fashion, by providing about 60% decrease of nitric oxide production at 25.0 µg/mL concentration (Kim et al., 2014).

Antifungal activity

The essential oil of *V. ferruginea* exhibited significant antifungal activity against dermatophyte strains with MIC between 0.16-0.64 µL/mL against *Epidermophyton floccosum*, *Trichophyton rubrum*, *T. mentagrophytes*, *Microsporum canis*, and *M. gypseum* (Cabral et al., 2008). The essential oil of *V. rivularis* exhibited significant antifungal activity against dermatophyte strains (*E. floccosum*, *T. rubrum*, *T. mentagrophytes*, *M. canis*, and *M. gypseum*) with MIC and MLC values ranging from 0.16 to 0.64 µL/mL and 0.32 to 2.5 mL/mL, respectively (Cabral et al., 2009).

Acaricidal activity

The toxicity against the coconut mite *Aceria guerreronis* showed that *V. gardneriana* essential oil had strong acaricidal activity, with an LC_{50} of 0.85 mg/mL. However, the essential oils of *V. capitata*, *V. megapotamica*, and *V. rufescens* plant did not kill adults of *A. guerreronis* over a period of 24 h. As a way of toxicity comparison, the acaricide abamectin, sprayed at its label rate, inflicted 100% mortality to *A. guerreronis* (De Sena Filho et al., 2017).

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Antibiofilm activity

Vale et al., (2019) reported that the biomass formation of *C. albicans* and *C. tropicalis* biofilm was inhibited after 24 h treatment with *V. gardneriana* essential oil. All concentrations tested were able to reduce *C. albicans* biomass. However, *C. tropicalis* biomass was inhibited at 2.5% to 0.312% oil concentrations. They concluded that the *V. gardneriana* essential oil reduced significantly the biofilm biomass and the number of viable cells of bacteria and yeasts, mainly on biofilm formation.

Larvicidal activity

The seasonal variation in essential oils of *V. gardneriana* was studied by Silva et al. (2019). The essential oils extracted in January (LC_{50} 78.3 µg/mL), March (LC_{50} 44.1 µg/mL), April (LC_{50} 47.9 µg/mL), May (LC_{50} 28.0 µg/mL), July (LC_{50} 43.5 µg/mL), August (LC_{50} 62.0 µg/mL), and December (LC_{50} 84.3 µg/mL) exhibited significant larvicidal activity against third instar larvae of *Aedes aegypti*.

Cytotoxic activity

The *V. gardneriana* essential showed that 0.3-1.25% concentrations had cytotoxic effects in L929 cell lines, whereas no significant cytotoxic effects in HaCat cell lines was observed (Vale et al., 2019).

Acetylcholinesterase activity

The essential oil of *V. gardneriana* displayed IC_{50} value of 11.2 mg/mL which was assessed using a thin layer chromatographic method (Pereira et al., 2018).

Conclusion

This review compiles the medicinal uses, chemical components, and biological activities of the *Vitex* essential oils. The studies managed to declare that the essential oils of *Vitex* genus contain monoterpenes and sesquiterpenes which potentially stimulate biological activities such as antioxidant, antimicrobial, anti-inflammatory, antifungal, acaricidal, antibiofilm, larvicidal, cytotoxic, and acetylcholinesterase properties. Undeniably, there are some current needs for other new plant-derived products to be tested for biological activity. The genus *Vitex* could be an imperative natural source for developing contemporary drugs and medicines.

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REFERENCES

Agalar, H. G., Ciftci, G. A., Yildirim, S. U., Goger, F., Kirimer, N. (2016). The LC/ESI-MSMS profiles and biological potentials of *Vitex agnus-castus* extracts. *Natural Product Communications*, *11*(11), 1655-1660.

Ahangarpour, A., Najimi, S. A., & Farbood, Y. (2016). Effects of *Vitex agnus-castus* fruit on sex hormones and antioxidant indices in a d-galactose-induced aging female mouse model. *Journal of the Chinese Medical Association*, *79*(11), 589-596.

Ahmad, F. B., & Holdsworth, D. K. (1995). Traditional medicinal plants of Sabah State Malaysia. Part III. *International Journal of Pharmacognosy*, *33*(3), 262-264.

Alice, C. B., Mentz, L., Siqueira, N. C. S., Silva, G. A. A. B., & Jose, K. F. (1995). *Plantas Medicinais De Uso Popular: Atlas Farmacognóstico.* ULBRA: Canoas, RS, Brazil.

Cabral, C., Gonçalves, M. J., Cavaleiro, C., Salgueiro. L., Antunes, T., Sevinate-Pinto, I., & Sales, F. (2008). *Vitex ferruginea* Schumach. et. Thonn. subsp. *amboniensis* (Gürke) Verdc.: glandular trichomes micromorphology, composition and antifungal activity of the essential oils. *Journal of Essential Oil Research, 20*(1), 86-90.

Cabral, C., Gonçalves, M., Cavaleiro, C., Sales, F., Boyom, F., & Salgueiro, L. (2009). Composition and anti-fungal activity of the essential oil from Cameroonian *Vitex rivularis* Gürke. *Natural Product Research, 23*(16), 1478-1484.

Callmander, M. W., Phillipson, P. B., & Schatz, G. E. (2014). Towards a Revision of the Genus *Vitex* L. (Lamiaceae) in Madagascar I: A Distinctive New Species from Northeastern Madagascar. *Candollea*, *69*(2), 141-147.

Ch. Nebie, R. H., Yaméogo, R. T., Bélanger, A., & Sib, F. S. (2005). Chemical composition of essential oils of *Vitex diversifolia Bak*. From Burkina Faso. *Journal of Essential Oil Research*, *17*(3), 276-277.

Dai, D. N., Thang, T. D., Ogunwande, I. A., & Lawal, O. A. (2015). Study on essential oils from the leaves of two Vietnamese plants: *Jasminum subtriplinerve* C.L. Blume and *Vitex quinata* (Lour) F.N. Williams. *Natural Product Research*, *30*(7), 860-864.

Damayanti, M., Susheela, M., & Sharma, G. J. (1996). Effect of plant extracts and systemic fungicide on the pineapple fruit-rotting fungus *Ceratocystis Paradoxa*. *Cytobios*, *86*(346), 155-165.

De Brum, T. F., Boligon, A. A., Frohlich, J. K., Schwanz, T. G., Zadra, M., Piana, M., & Athayde, M. I. (2013). Composition and antioxidant capacity of the essential oil of leaves of *Vitex megapotamica (Sprengel) Moldenke*. *Natural Product Research, 27*(8), 767-770.

De Sena Filho, J. G., Barreto, I. C., Soares Filho, A. O., Nogueira, P. C., Teodoro, A. V., Cruz Da Silva, A. V., Xavier, H. S., Rabbani, A. C., Spakowicz, D. J., & Duringer, J. M. (2017). Volatile metabolomic composition of *Vitex* species: Chemodiversity insights and acaricidal activity. *Frontiers in Plant Science, 8*, 1931-1939.

Devi, W. R., & Singh, C. B. (2014). Chemical composition, anti-dermatophytic activity, antioxidant and total phenolic content within the leaves essential oil of *Vitex trifolia*. *International Journal of Phytocosmetics and Natural Ingredients, 1*(1), 5-10.

Duymus, H. G., Ciftci, G. A., Yildirim, U., Demirci, B., Kirimer, N. (2014). The cytotoxic activity of *Vitex agnus castus* L. essential oils and their biochemical mechanisms. *Industrial Crops and Products*, *55*, 33-42.

Dykgraaf, A. C. (1992). *Princely Puriri, 13*. New Zealand Geography.

Geetha Nambiar, M. K. (1994). *Analysis of essential oils of Vitex negundo var. negundo & Vitex negundo var. purpurescens. Isolation, structural elucidation and biological properties of secondary metabolites in some plant.* Department of Chemistry, University of Calicut.

Goncalves, J. (2001). Antiviral effect of flavonoid-rich extracts of (Verbenaceae) against acyclovir-resistant herpes simplex virus type 1. *Phytomedicine*, *8*(6), 477-480.

Haghighi, T. M., Saharkhiz, M. J., Naddaf, F. (2019). Ontogenetic variability of *Vitex pseudo-negundo* essential oil and its phytotoxic activity. *Scientia Horticulturae*, *257*, 108735.

Khan, M. F., Arora, P., & Dhobi, M. (2019). A prospective review on phyto-pharmacological aspects of *Vitex negundo* Linn. *Current Traditional Medicine,* http://doi.org/10.2174/2215083805666191021161005

Kilani, A. M. (2006). Antibacterial assessment of whole stem bark of *Vitex doniana* sweet against some *Enterobactriaceae*. *African Journal of Biotechnology, 5*(10), 958-959.

Kim, C., Bu, H. J., Lee, S. J., Hyun, C.G., & Lee, N. H. (2014). Chemical compositions and anti-inflammatory activities of essential oils from *Aster spathulifolius* and *Vitex rotundifolia* Maxim*. Journal of Applied Pharmaceutical Science,* 4(10), 12-15.

Kok, R. D. (2008). *The genus Vitex (Labiatae) In the Flora Malesiana Region, Excluding New Guinea*. *Springer Netherlands, 63*, 17-40.

Koudou, J., Ouoba, A. M., Some, N., Ouedraogo, S., & Guissou, I. P. (2014). Acute toxicity and irritancy of the essential oil of the leaves of *Vitex simplicifolia* Oliv. (Verbenaceae) In Burkina Faso. *Journal of Pharmacology and Toxicology, 9*(1), 62-67.

Leitao, S. G., Fonseca, E. N., & dos Santos, T. C. (1999). Essential oils from two Brazilian *Vitex* species. *Acta Horticulturae, 500*, 89-92.

Li, S., Zhang, H., Qiu, S., Niu, X., Santarsiero, B. D., Mesecar, A. D., & Sun, H. (2002). Vitexlactam a, a novel labdane diterpene lactam from the fruits of *Vitex agnus-castus*. *Tetrahedron Letters*, *43*(29), 5131-5134.

Makwana, H. G., Ravishankar, B., Shukla, V. J., Bhaskarannair, R., Vijayan, N. P., Sasikala, C. K., Saraswathy, V. N., & Bhatt, S. V. (1994). General pharmacology of *Vitex leucoxylon* Linn leaves. *Indian Journal of Physiology and Pharmacology, 38*(2), 95-100.

Niazi, A., Rahimi, V. B., Hatami, H., Shirazinia, R., Esmailzadeh-dizaji, R., Askari, N., Askari, V. R. (2019). Effective medicinal plants in the treatment of the cyclic mastalgia (breast pain): a review. *Journal of Pharmacopuncture*, *22*(3), 131-139.

Niroumand, M. C., Heydarpour, F., & Farzaei, M. H. (2018). Pharmacological and therapeutic effects of *Vitex agnus-castus* L: A review. *Pharmacognosy Reviews, 12*(23), 103-114.

Nyiligira, E., Viljoen, A., Başer, K., Õzek, T., Van Vuuren, S., & Houghton, P. (2004). Essential oil composition and in vitro antimicrobial and anti-inflammatory activity of South African *Vitex* species. *South African Journal of Botany, 70*(4), 611-617.

Ondo, J. P., Lekana-Douki, J. B., Bongui, Zangedou, E. S., Zatra, R., Toure-Ndouo, F. S., & Elomri, A. (2012). In vitro antiplasmodial activity and cytotoxicity of extracts and fractions of *Vitex Madiensis*, medicinal plant of Gabon. *Tropical Medicine and International Health*, *17*(3), 316-321.

Ono, M., Yanaka, T., Yamamoto, M., Ito, Y., & Nohara, T. (2002). New diterpenes and norditerpenes from the fruits of *Vitex rotundifolia. Journal of Natural Products, 65*, 357-541.

Pereira, E. J., Do Vale, J. P., Da Silva, P. T., Lima, J. D., Alves, D. R., Costa, P. S., Santos, H., Rodrigues, T. S., Menezes, J. S., Morais, S. M., Bandeira, P. N., & Fontenelle, R. S. (2018). Circadian rhythm, and antimicrobial and anticholinesterase activities of essential oils from *Vitex gardneriana*. *Natural Product Communications*, *13*(5), 635-638.

Rahman, M. S., & Bhattacharya, G. N. (1982). Effects of leaf extract of *Vitex Negundo* on *Lathyrus satitus* Linn. used to protect stored grains from insects. *Current Science, 51*(8), 434-435.

Rani, A., Sharma, A. (2013). The genus *Vitex*: A review. *Pharmacognosy Reviews*, *7*(14), 188-198.

Salleh, W. M. N. H. W., Ahmad, F., Khong, H. Y., & Sirat, H. M. (2011). Chemical compositions, antioxidant and antimicrobial activities of the essential oils of *Piper caninum* Blume. *International Journal of Molecular Sciences*, *12*(11), 7720-7731.

Salleh, W. M. N. H. W., Ahmad, F., Khong, H. Y., & Sirat, H. M. (2012). Chemical compositions, antioxidant and antimicrobial activities of the essential oils of *Piper officinarum* C.DC (Piperaceae). *Natural Product Communications*, *7*(12), 1659-1662.

Salleh, W. M. N. H. W., Ahmad, F., & Khong, H. Y. (2014a). Chemical composition and antimicrobial activity of essential oil of *Piper muricatum* Blume (Piperaceae). *Journal of Essential Oil Bearing Plants*, *17*(6), 1329-1334.

Salleh, W. M. N. H. W., Ahmad, F., & Khong, H. Y. (2014b). Chemical compositions and antimicrobial activity of the essential oils of *Piper abbreviatum*, *P. erecticaule* and *P. lanatum* (Piperaceae). *Natural Product Communications*, *9*(12), 1795-1798.

Salleh, W. M. N. H. W., Ahmad, F., & Khong, H. Y. (2014c). Chemical composition of *Piper stylosum* Miq. and *Piper ribesioides* Wall. essential oils and their antioxidant, antimicrobial and tyrosinase inhibition activities. *Latin American and Caribbean Bulletin of Medicinal and Aromatic Plants*, *13*(5), 488-497.

Salleh, W. M. N. H. W., Ahmad, F., Khong, H. Y., & Zulkifli, R. M. (2015a). Chemical compositions and biological activities of essential oils of *Beilschmiedia glabra*. *Natural Product Communications*, *10*(7), 1297-1300.

Salleh, W. M. N. H. W., Ahmad, F., & Khong, H. Y. (2015b). Chemical compositions and biological activities of the essential oils of *Beilschmiedia madang* Blume (Lauraceae). *Archives of Pharmacal Research*, *38*, 485-493.

Salleh, W. M. N. H. W., Ahmad, F., & Khong, H. Y. (2015c). Antioxidant and anticholinesterase activities of essential oils of *Cinnamomum griffithii* and *C. macrocarpum*. *Natural Product Communications*, *10*(8), 1465-1468.

Silva, P., Santos, H., Teixeira, A., Bandeira, P., Holanda, C., Vale, J., & Santiago, G. (2019). Seasonal variation in the chemical composition and larvicidal activity against *Aedes aegypti* of essential oils from *Vitex gardneriana* Schauer. *South African Journal of Botany, 124*, 329-332.

Sonibare, O. O., Effiong, I., Oladosu, I., & Ekundayo, O. (2009). Chemical constituents and antimicrobial activity of the essential oil of *Vitex doniana* sweet (Verbernaceae). *Journal of Essential Oil Research, 12*(2), 185-188.

Suchitra, M., & Cheriyan, B.V. (2018). *Vitex trifolia*: An ethnobotanical and pharmacological review. *Asian Journal of Pharmaceutical and Clinical Research, 11*(4), 12-14.

Suksamrarn, A., Aphaijitt S., Brophy, J. J. (1990). The volatile leaf oil of *Vitex limonifolia* Wall. *Flavour and Fragrance Journal*, *5*(1), 53-55.

Tereza, C. S., Jan, S., Franco, D. M., & Suzana, G. (2001). Iridoids from *Vitex cymosa. Journal of the Brazilian Chemical Society, 12*(6), 763-766.

Tian, Z., & Liu, X. (2018). Chemical composition and antioxidant activity of the seeds oil of *Vitex kwangsiensis* C. Pei. *Records of Natural Products, 12*(6), 630-633.

Toplan, G. G., Kurkcuoglu, M., Baser, K. H. C., Sariyar, G. (2015). Composition of the essential oils from samples of *Vitex agnus-castus* L. growing in Turkey. *Journal of Essential Oil Research*, *27*(4), 337-342.

Vale, J. P., Ribeiro, L. H., Vasconcelos, M. A., Sá-Firmino, N. C., Pereira, A. I., Nascimento, M. F., & Teixeira, E. H. (2019). Chemical composition, antioxidant, antimicrobial and antibiofilm activities of *Vitex gardneriana* Schauer leaves' essential oil. *Microbial Pathogenesis, 135*, 103608.

Wang, L., & Weller, C.L. (2006). Recent advances in extraction of nutraceuticals from plants. *Trends in Food Science & Technology, 17*(6), 300-312.

Yamasaki, T., Kawabata, T., Masuoka, C., Kinjo, J., Ikeda, T., Nohara, T., & Ono, M. (2008). Two new lignin glucosides from the fruit of *Vitex cannabifolia. Journal of Natural Medicines, 62*, 47-51.

Yoganarasimhan, S. N. (2000). *Medicinal Plants of India: Tami Nadu.* Cyber Media, Bangalore.

Zerbo, P., Millogo Rasolodimby, J., Nacoulma Ouedraogo, O., & Van Damme, P. (2011). Plantes médicinales et pratiques médicales AU Burkina Faso: Cas des *Sanan*. *Bois & Forets Des Tropiques*, *307*, 41.